Cross Slope

Typical Section Details & Constructability

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Cross Slope Training Outline

- Milling & Paving Equipment
  - Information Contractors Need
- Milling & Paving Scenarios
  - Project Typical Sections
    - Check List of Typical Section details
      - What Contractors Need
      - What Can Create Confusion
    - Example Typical Sections
      - The Good, The Bad & The Ugly

A Few Words

- Cover what's needed from contractor perspective
- Covers most situations
  - The "Typical Typicals"
- There are other Design & Construction Challenges
  - However, today we'll discuss Typical Section Details needed for construction

Thanks

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  - Stacy Scott
  - Greg Sholar
  - Clay Whittaker

Milling & Paving

Milling

Milling Drum

Milling Drum

Milling Drum

Milling Drum

Grinder

Milling Machine

- Two Controls to Set – one for each side
  - Set milling depth on each side

  OR
  - Set depth at control point (one side) & cross slope from that point

Milling Machine Controls

Milling Machine

- Typical Section must either provide:
  - One Constant Milling Depth for the lane
    - Set both milling controls to same depth
    - Don't list it as "Average"
  - Depth on One Side & Cross Slope
    - Set depth on one side of lane & slope to the other side of lane
    - This requires a milling control point on typical section
      - So contractor knows which control is set to depth (other set to slope)

Milling Machine

- Most milling is done with two passes per lane
  - Typically 6ft to 7ft milling drum width

Paving

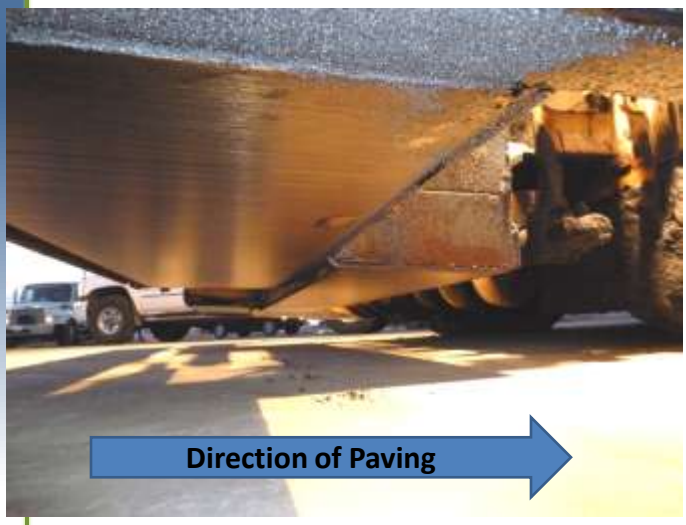
Paving with Material Transfer Vehicle (aka Shuttle Buggy)

Paving

Paving Equipment

- 8-10 ft wide screed
  - Typical (& preferred) screed width is 10 ft
- Extendable screeds allow paving to 20ft width

Paver Screed

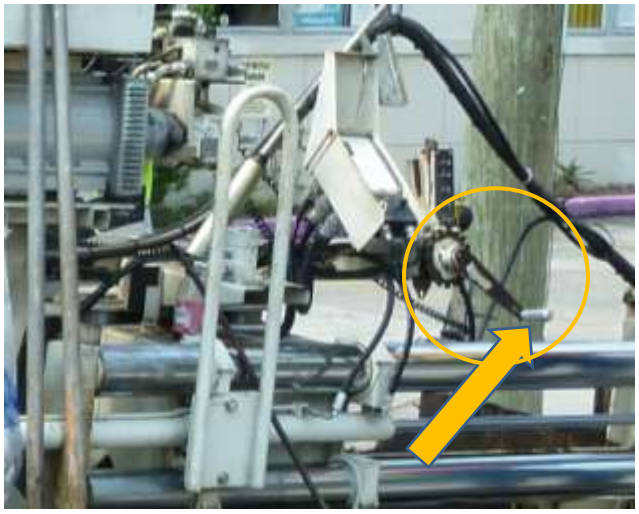


Pavement Depth Checker

Paver Depth Controls

Paver Depth Controls

Paver Depth Controls



Checking slope with 4ft level

Paver Cross Slope Control

Joint Matcher

Paving Equipment

- Controls
  - Depth is set manually by paving crew
  - Paver has electronic cross slope control
  - Ski pole & other electronics help provide smooth longitudinal profile

Paving Equipment

- Typical Section must either provide:
  - One Uniform Thickness for the lane
    - Set same thickness on each side of paver
    - Don't list it as "Average"
  - Depth on One Side & the Cross Slope
    - Set depth on one side and slope
    - Also requires a profile grade line on the typical section
      - minimum of one per set of adjoining lanes

Milling & Paving

- Accuracy
  - Provide % Slopes to nearest 0.1%
    - Most Slope Controls only go to tenths
      - On typical section list slope as 1.8% (or 0.018)
  - Provide Depths to nearest ¼"
  - More precise plan values will be modified to tenths by project personnel

Four "Tools in the Tool Box"

- <u>Milling</u>
  1. Constant Depth
     - Slope: matches existing - variable
  2. Constant Slope
     - Depth: depends on existing - variable
- <u>Paving</u>
  3. Constant Thickness - Standard Paving
     - Slope: matches slope of surface being paved on
  4. Constant Slope – Overbuild
     - Thickness: depends on surface being paved on

Project scenarios are a combination of the 4 options

Typical Section Scenarios

- Match Existing
  - No Cross Slope Correction
  1. Mill for Depth, Pave Constant Thickness
- Cross Slope Modification
  2. Mill for Slope, Pave Constant Thickness Structural / Friction
  3. Mill for Depth, Correct Slope with Overbuild, Pave Constant Thickness Structural / Friction
  4. Mill for Slope, Finish Correcting Slope with Overbuild, Pave Constant Thickness Structural / Friction

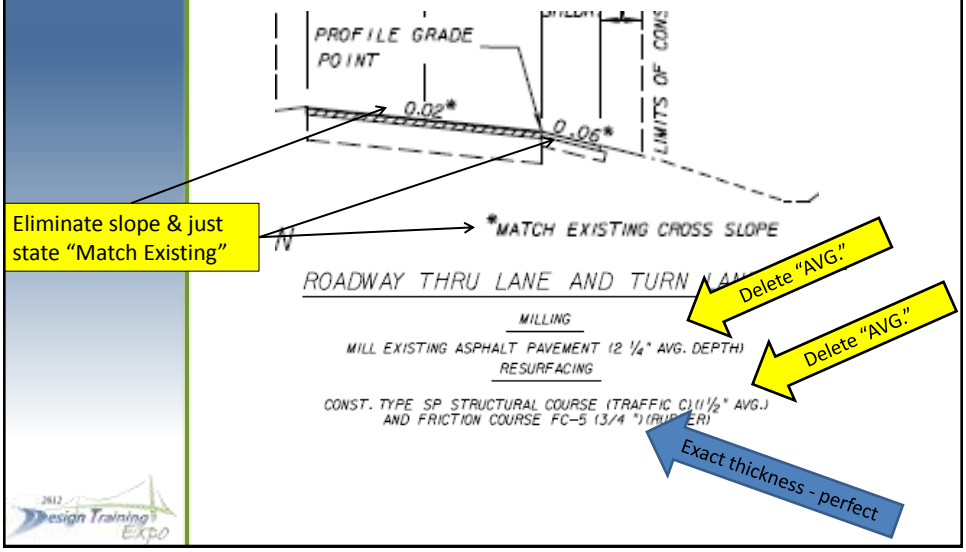
Match Existing Typical Section Check List

- Mill for Depth
- Pave Constant Thickness

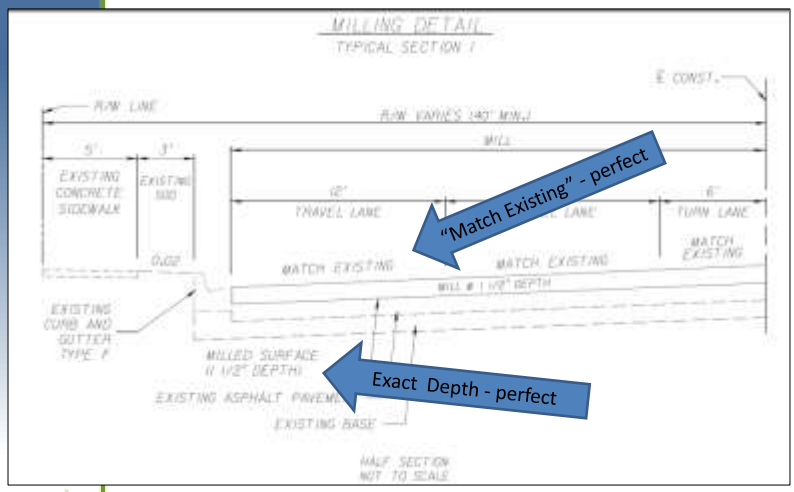
Match Existing Typical Section Check List

- Mill for Depth
  - Provide Single, Uniform Milling Depth
  - Not an "Average", list it as exact
- Pave Constant Thickness
  - Provide Uniform Thickness for each course
  - Not an "Average", list it as exact
- Don't include a Design (or target) Slope
  - Can either match existing or mill & pave to a design slope
  - Contractor can't do both
- If "existing slope" is shown:
  - Clearly identify it as "existing slope"
  - Otherwise it can be confused as a design slope
  - Recommend leaving existing slope off typical section
  - If desired add a plan note stating approx. slope range

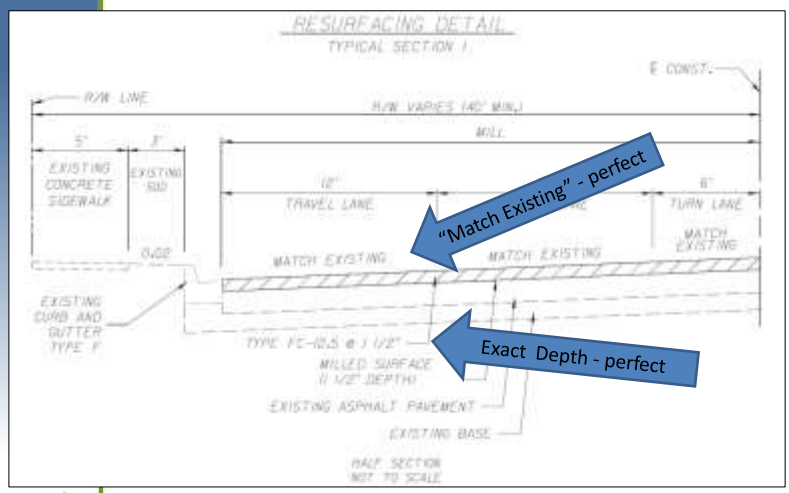
Delete Existing slope value
Delete AVG from milling depth & paving thickness



Match Existing
Good Milling Detail



Match Existing
Good Resurfacing Detail



Cross Slope Modifications

- Next three scenarios
  - Options for cross slope modification
- The "Match Existing" recommendation regarding "NOT providing a slope when paving constant thickness", changes here

Cross Slope Modifications

- End goal is the design slope
- Slope achieved by:
  - Milling for slope
  - Paving overbuild
  - Both
- Minor slope adjustments ARE made with "constant thickness" asphalt
  - Therefore, provide exact constant thickness AND design cross slope shown on Typical Section
    - Differs from match existing

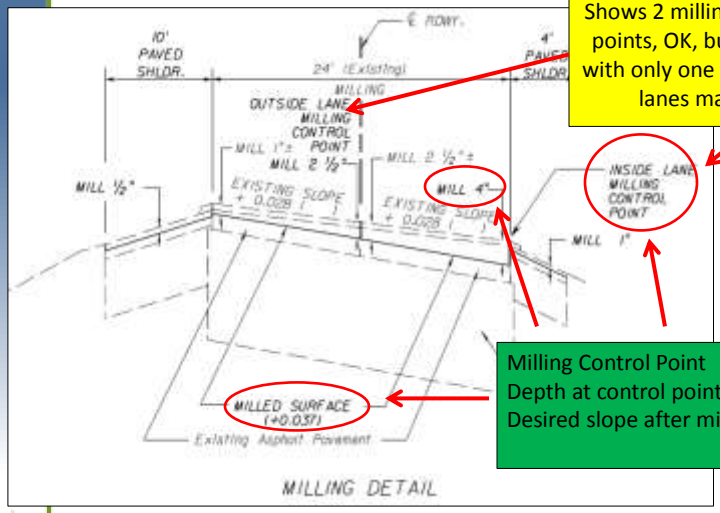
Mill Slope
Pave Constant Thickness

- Cross Slope Modification
  - Mill for Slope,
  - Pave Constant Thickness Structural & Friction

Typical Section Check List
Mill Slope, Pave Constant Thickness

- <u>Mill for Slope</u>
  - Provide Exact Milling Depth on one side of lane
  - Provide Milling Control Point on same side of lane
  - Provide Exact Desired Cross Slope – No +/-
    - Spec provides allowable construction tolerances
    - Adjacent lanes can just show slope, don't need control point on each lane
- <u>Pave Constant Thickness</u>
  - Provide Uniform Thickness for each Course
  - Provide Design Slope – see explanation on "Cross Slope Modifications" slide
- Don't list Average (Depths or Thicknesses)
- If desired, add plan note with "Avg Milling Depth"

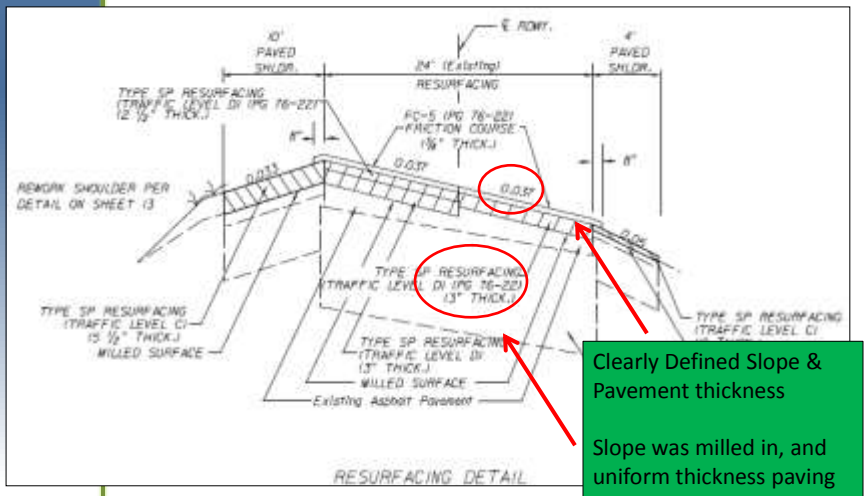
Milling to Change Slope



Shows 2 milling control points, OK, but better with only one to ensure lanes match

Milling Control Point
Depth at control point
Desired slope after milling

Paving Constant Thickness



Clearly Defined Slope & Pavement thickness

Slope was milled in, and uniform thickness paving should achieve slope, but if it doesn't, contractor will maintain slope.

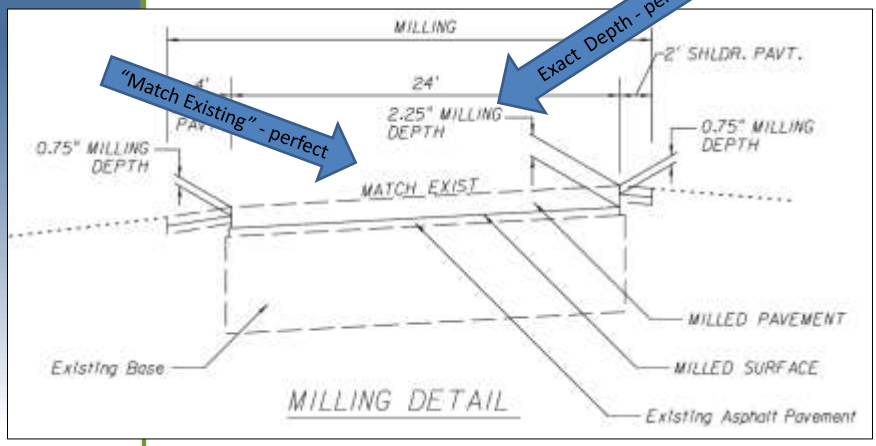
Mill Depth
Correct Slope with Overbuild

- Cross Slope Modification
  - Mill for Depth
  - Correct Slope with Overbuild
  - Pave Constant Thickness Structural / Friction

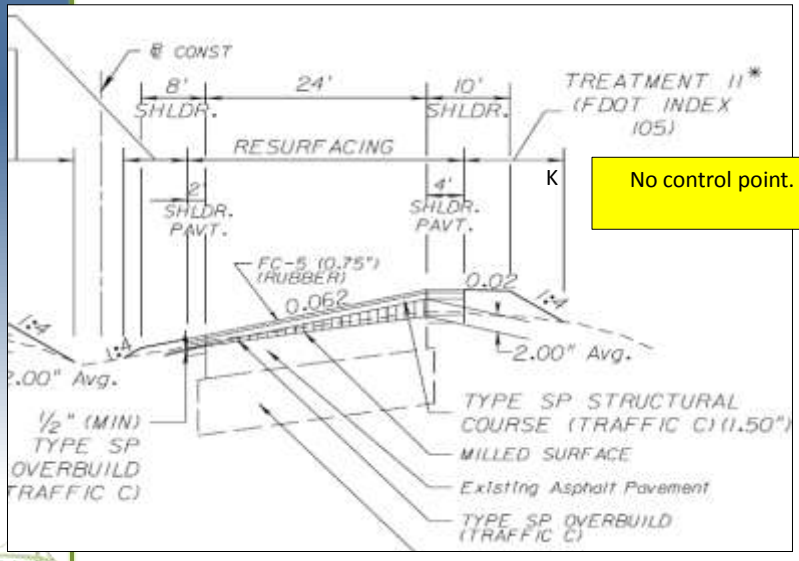
Mill Depth
Correct Slope with Overbuild

- <u>Mill for Depth</u>
  - Provide Single, Uniform Milling Depth
    - Not an "Average", list it as exact
- <u>Pave Slope with Overbuild</u>
  - Provide Desired Cross Slope for Overbuild
  - Provide a Profile Grade Line/Control Point & Thickness at that point
    - Adjacent lanes can just show slope, don't need control point on each lane
  - Don't specify mixes or min and max thicknesses, let Spec dictate mix used
  - Eliminate Existing Slope, or if listed, identify it is as existing
  - For each Lane, provide Table of Greatest Overbuild Thicknesses (for each 500ft section of pavement)
- <u>Pave Constant Thickness</u>
  - Provide Single, Uniform Paving Thickness
    - Not an "Average", list it as exact
  - Provide Design Slope – see explanation on "Cross Slope Modification" slide

Milling for Depth

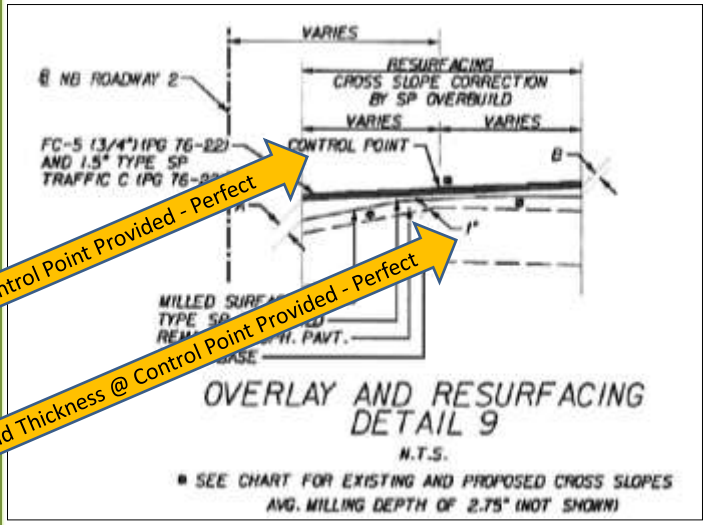


Overbuild



No control point.

Overbuild – Control Point & Thickness Details



Control Point Provided - Perfect

Overbuild Thickness @ Control Point Provided - Perfect

Overbuild

- AVG Thickness for a Typical Section
  - Not useful for setting up paver
- For paver set up, provide:
  - Control Point
  - Exact thickness at control point
  - Cross Slope
- Average Thickness Table at a regular frequency is useful
  - Helps contractor plan the work
  - One pass, two passes, etc.

Overbuild Table

STA.	SIDE	LANES			AVG. HT. OF OVERBUILD (IN.)	AREA OVERBUILD (SY)	TOTAL SP OVERBUILD (TN)
		EXIST. SLOPE	PROP. SLOPE	MAX. HT (IN.) 'A'			
475+00	LT	-0.018	-0.020	0.00	0.43	118.28	5.0
475+50	LT	-0.016	-0.020	0.43	1.03	118.28	5.0
476+00	LT	-0.016	-0.020	1.03	1.03	118.28	5.0
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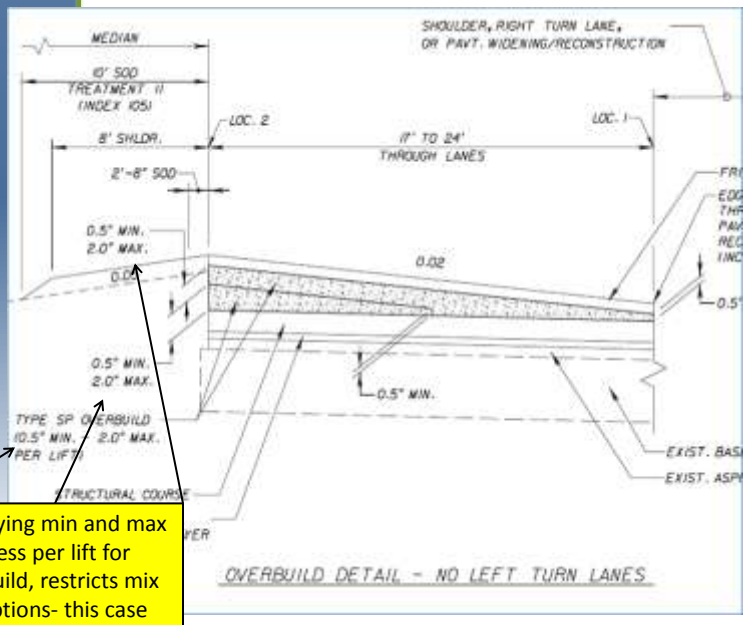
477+20	LT	-0.015	-0.020	1.75	1.12	47.31	2.9
478+00	LT	-0.014	-0.020	1.51	1.00	109.24	10.5
478+50	LT	-0.012	-0.020	1.99	1.24	118.28	8.1
479+00	LT	-0.010	-0.020	2.47	1.48	118.28	9.7
479+50	LT	-0.013	-0.020	1.87	1.18	118.28	7.7
480+00	LT	-0.01	-0.020	2.23	1.36	118.28	8.9
480+50	LT	-0.010	-0.020	2.59	1.54	118.28	10.0
481+00	LT	-0.01	-0.020	2.35	1.42	118.28	9.3
481+50	LT	-0.007	-0.020	3.31	1.90	118.28	12.4
481+75	LT	-0.006	-0.020	3.67	2.08	59.14	6.8
482+00	LT	-0.003	-0.020	4.39	2.44	59.14	8.0
482+25	LT	-0.004	-0.018	3.47	1.98	59.14	6.5
482+50	LT	-0.007	-0.013	1.57	1.03	59.14	3.4
483+00	LT	-0.002	-0.004	0.52	0.51	118.28	3.3
483+50	LT	0.005	0.005	0.00	0.25	118.28	1.6
484+00	LT	0.02	0.015	-0.73	0.00	118.28	0.0
484+50	LT	0.028	0.024	0.98	0.74	118.28	4.8
485+00	LT	0.032	0.033	0.00	0.25	118.28	1.6
485+50	LT	0.043	0.042	0.04	0.30	118.28	1.9
							144.5

A table of average heights at given stations is preferred over an average thickness for the typical section

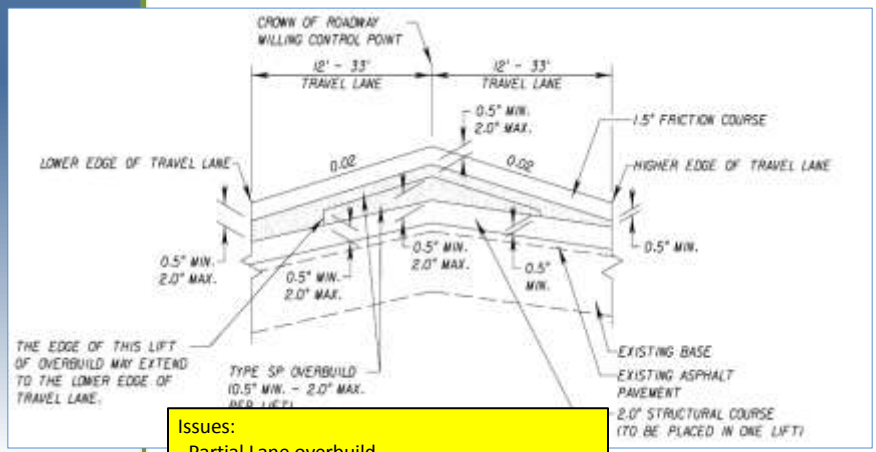
Mill for Slope
Correct Slope with Overbuild

- Mill for Slope
  - Provide Exact Milling Depth on one side of lane
  - Provide Milling Control Point on same side of lane
    - Adjacent lanes can just show slope, don't need control point on each lane
  - Provide Exact Target Cross Slope
    - Spec provides allowable construction tolerances
- Pave Slope with Overbuild
  - Provide Target Cross Slope for Overbuild
  - Provide a Profile Grade Line/Control Point & Thickness at that point
    - Adjacent lanes can just show slope, don't need control point on each lane
  - Don't specify mixes or min and max thicknesses, let Spec dictate
  - Eliminate Existing Slope, or if listed, identify it as existing
  - For each Lane, provide Table of Greatest Overbuild Thicknesses (per 500ft)
- Pave Constant Thickness
  - Provide Single, Uniform Paving Thickness
    - Not an "Average", list it as exact
  - Provide Design Slope – see explanation on "Cross Slope Modification" slide



Specifying min and max thickness per lift for overbuild, restricts mix size options- this case limits overbuild to a 9.5mm mix

Overbuild Issues



Issues:
- Partial Lane overbuild
- No clear control
- Multiple lifts of 9.5, due to lift thickness restrictions (min & max)

Keep it Simple

- Keep it simple,
  - "Someone has to build this ------!"
- Design Intent must be clearly communicated to the field personnel
- If not, likely it will not be built as designed

Keep it Simple

- Too many typical sections aren't good either
  - Difficult to construct & transition between each typical section
    - Remember we are trying to pave a smooth road
  - Keep number of scenarios to a minimum
  - Rule of Thumb: One typical section for each scenario
  - Need typical sections for accel/decel lanes
    - if there are different milling & paving scenarios

Constructability

- Make required changes with minimum number of Typical Sections
- Too many typical sections can adversely affect smoothness
- Consistency & Uniformity
  - Keep a smooth constant flow when paving
  - Keep # of grade or slope changes reasonable
    - Changing too often doesn't lead to smooth ride
- Challenge is to balance smoothness & cross slope
  - Longer transition lengths are key to providing a smooth pavement

Average – Depth or Thickness

- They are "Nice to know" info
- Can't set milling & paving equipment to an Average Depth or Average Thickness
- Provide exact depths, and/or exact slopes
- Provide Milling Control Point/Profile Grade Line as needed
  - Minimum of one per set of adjoining lanes

Milling Control Point / Profile Grade Line

- Dictates controlling point of roadway cross section
- Critical when slope corrections are made
- Need one control point per set of adjoining lanes
  - Regardless of direction of traffic
    - ex 2 lane roadway - one control point

Milling Control Point / Profile Grade Line

- Normally don't need more than one control point per set of adjoining lanes
  - Can have more, ex. one for each lane
    - Be careful if you do this
    - It isn't typical
    - Can get you into trouble with final surface of lanes not matching (big problem)

Overbuild

- Typically used when unable to correct slope by milling
- If possible:
  - Keep overbuild low in pavement structure
  - Keep from making overbuild last lift prior to friction course
  - Try to place at least one structural lift on top of overbuild
  - Why?
    - Typically overbuild has variable density
    - Placing it lower improves ride smoothness
    - Constant thickness lifts typically perform better than overbuild

Overbuild

- Try not to eliminate any options for contractor
- Don't specify min & max lift thickness
  - Let Specs dictate mix size & lift thicknesses
- Focus on overall thickness & slope
- Consider MOT impacts, can only pave one lane at a time

Conflicting or Unclear Information

- Leads to confusion & arguments
  - Intent may be clear to designer
  - But it needs to be clear to project staff
- Can Increase Project Time & Cost
- Leads to As-Built Cross Slope being different from Design Slope

Future

- Use of “Cross Slope van” data
- LiDar
- Other technologies
- CIM
- ???

Questions & Discussion

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